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MANIFESTATIONS OF THE ETHER.

THE purpose of this article is to present to the non-technical reader a very brief review of modern ideas concerning the universal ether and some of its manifestations in the material world around us.

A few of the wise philosophers of olden times dimly imagined that there might be such a medium as the ether, yet little more than a century has elapsed since its existence was first seriously considered or admitted by a few advanced investigators, and even then only to accommodate and establish the undulatory theory of light. It is now recognized not only as the vehicle of light, heat and other radiant forces, but it is accepted by many scientists as the ultimate basis of the material universe.

This sweeping conception points to the absolutely immaterial origin of matter, and to its actual creation by superphysical means from this profoundly wonderful, unlimited, intangible and almost inconceivable entity,—the universal ether.

The phenomenon of light is one of its most familiar manifestations. We are accustomed to consider light as the antithesis of darkness, and the term is generally used to indicate the sensation produced in our organs of vision by ether waves of certain well-known frequencies and amplitudes.

All ether waves, however, which have the same physical characteristics as those which produce for us the vis-

ible spectrum may be classed with light waves, but it has become customary to generalize them under the common term of "rays," as for example, thermal or heat rays, ultra-violet or chemical rays, X-rays and so forth. There are other phenomena which have been also generalized under the same term although they are not produced by ether waves, but by the rapid flight of minute particles of electrified matter, or of electrons. In this category belong cathode and canal rays, also the alpha and beta rays which emanate from radium.

Etheric waves include a vast field of frequencies, beginning we know not how far down the scale, but first recognized in the electric waves of low frequency and great amplitude which were so brilliantly predicated by Maxwell in 1864, and afterwards discovered and demonstrated with exquisite skill by Hertz in 1888. Then sweeping upwards with ever increasing frequency and diminishing amplitude through a great unknown region, these ethereal undulations are next manifested in the heat spectrum which was so ingeniously explored and mapped out by Langley and other investigators.

Then passing from the heat rays, we see them dimly dawning in the first red beams of visible light, and now brightening and shining through all the rainbow hues of the visible spectrum until at length they fade into violet twilight and sink again into darkness. Yet not lost, but next manifested in the ultra-violet or chemical spectrum, and then through another vast and unexplored expanse to the region of the so-called X rays, and presumably onward from thence towards a vanishing point of infinite frequency and zero amplitude.

Considering the extent of the visible spectrum as one octave in this vast scale of etheric notation the invisible heat spectrum may be said to extend about five octaves below it. Still lower in the scale there are many octaves

of the vast unknown spectrum which exists between the longest heat waves and the shortest electric waves that are used in wireless telegraphy, etc. Above the single octave of visible light waves are found about two octaves of invisible ultra-violet or actinic waves. Then come seven or eight octaves of another great unexplored and unknown spectrum beyond which appear the X rays of varying qualities and probably the gamma rays of radium. These are believed to be manifestations of ethereal pulses having the highest frequency and the shortest amplitude thus far discovered, for of the region beyond nothing is yet known.

It is doubtful if we shall ever be able to comprehend the full compass of this vast and magnificent ethereal scale owing to the limitations of our perceptive powers, but enough of it has been revealed and understood to sharpen our desires for a broader knowledge and a clearer insight, and just as Maxwell was enabled to predict, and Hertz to produce and demonstrate the low frequency electric waves, and as Roentgen was led to discover and make visible the high frequency X rays, so will other investigators in this infinite field of research be inspired to unfold and bring to light many new manifestations that are now hidden from our view.

The tendencies of ignorance and barbarism are to scatter and divide, but the trend of advancing knowledge and civilization is to consolidate and unify. The early promptings of man's religious inclinations persuaded him to imagine that each object in nature was controlled by its own peculiar deity. He had "gods many and lords many" but with the development of higher mental qualifications, he became satisfied to believe in the existence and government of one God. So also many of the old philosophers believed in a multitude of various "virtues" or "emanations," each of which was supposed to be the origin of one particular natural phenomenon. Thus there was one virtue or ema-

nation that produced light, another heat, another magnetism, and so forth. In striking contrast to this heterogeneous multiplicity of scattered causes, let us consider the grand simplicity of the natural forces when demonstrated to us as only the varied but consistent manifestations of one universal medium. And yet who can feel surprise that these older ideas should have been conceived, for they were apparently based on principles of fact and common sense. How differently, for example, do light and heat appeal to our sense perceptions, and who would naturally suppose that each of these sensations is caused by the same order of ethereal undulations? So also with the electric waves of Maxwell and Hertz, and Roentgen's X rays, to all of which our senses are impassive and which are only revealed to us by their secondary effects. How could any superficial observation of these phenomena inform us that they are all due to a series of ethereal waves which differ only in magnitude and frequency from other waves that convey to us the sensations of light or of heat?

Having thus very briefly considered some of the natural forces as manifestations of the ether, let us now turn our attention to tangible matter.

Within comparatively recent times the indestructibility of matter was hardly questioned, and the absolute permanence and indivisibility of the material atom was generally acknowledged. New elements were being discovered by the chemist and we were growing somewhat confused by the ever increasing number of presumably unalterable and eternally permanent elementary substances. For some obscure reason the scientific mind often rebelled, at least inwardly if not openly, against this ever growing complicity in nature and yearned for basic simplicity and unification. How pleasing and satisfying therefore is the prospect of solving this perplexing question by the revelation of a material monism that is based upon a rational

interpretation of indisputable facts, and which appeals with equal force to both reason and idealism.

The so-called elementary substances were long ago separated into their constituent molecules and the molecules were divided into atoms, but here we came to a standstill until the electronic hypothesis suggested the subdivision of the atom into its ultimate particles. These transcendently minute entities which Dr. Johnstone Stoney very aptly termed "electrons" have been most carefully and diligently studied, but it is possible that their structural mechanism may never be clearly determined and understood. It is however probable that they are simply differentiated ether whirls or vortices that are endowed with intense activities of unknown, perhaps unknowable, origin. The material atom, far removed from individual inspection by reason of its infinitesimal size, is yet of colossal proportions when compared with the inconceivably minute ethereal monads which are believed to perform their orderly planetary evolutions within its boundaries, and the suggestion is offered that it is their relative numbers and their respective groupings and velocities, together with the scope and general characteristics of their orbits, that individualizes their containing atom, which in turn determines the physical qualities of the so-called elementary substance of which it may form a part.

The interatomic spaces between these electrons may be comparable to planetary spaces, and it is at least conceivable that the mechanics of the visible universe may be typical of atomic structure, making the infinitely great emblematical of the infinitely small, and thus, quoting the words of Professor Serviss, "Starting from the smallest things of which we can have any knowledge and rising to the greatest things which the universe presents, we may find everywhere a single plan running through them all,

the stupendous star cluster showing us an image of the infinitesimal atom."

According to this hypothesis, therefore, the entire material cosmos may be considered as simply a manifestation of the ether. Ether points endowed superphysically with various activities appearing as electrons, systems of electrons of more or less complexity, forming atoms, atoms combining into molecules, and molecules building up matter in all its various physical forms and countless combinations. So also, on the other hand, motions and strains communicated to the surrounding ether by atomic or interatomic activities are manifested in the various natural forces, which in their turn again affect other material atoms or their constituent parts. The unending cycles of cause and effect are thus continued, and we have found that although when at rest and under no strain, the ether appears to us as nothing, yet when endowed with motion and under strain it becomes everything.

All substantial matter and all intangible forces, all things in fact of a physical character that our senses can perceive or our minds can contemplate are resolvable into manifestations of this wonderful medium. Thus far has science seemingly traced back matter and energy to their sources: ether and motion, but here the limit of human understanding is reached. The First Great Cause of physical phenomena is still beyond us and we are again confronted with the time - worn question, "Canst thou by searching find out God?"

These far-reaching conceptions which are alike attractive in their beautiful simplicity and their mysterious depth, point to the possible explanation of some hitherto troublesome problems. For example, they entirely dispose of that logical absurdity the solid indivisible and indestructible atom, and at the same time illustrate in a rational manner how the most minute of material entities

may have a conceivable origin. They also throw some light on the mysterious force of gravitation, resolving it into an ether strain dependent on the interrelation between the spinning systems of ethereal monads and their containing medium.

The activities of these cycling electrons being in general ungoverned by known physical laws would account for the apparently unchangeable nature of so-called elementary bodies. Yet we know that at least some of these bodies are not unchangeable, for the discovery of radioactive matter has revealed the extraordinary fact that certain elements appear to undergo a continuous process of spontaneous disintegration and subsequent reconstruction into other elements of more simple physical constitution, as shown for example in the gradual evolution of helium from radium, which will be referred to again later on.

To all commonplace intents and purposes however that which is usually termed elementary matter may be considered stable, because atomic changes are so inconceivably gradual and minute that they cannot be measured, excepting by indirect and very difficult methods, and even then only in connection with a few substances which are remarkable for their high atomic weight and strong radioactive properties.

To illustrate the exceedingly minute character of these atomic changes and to show how utterly impossible it would be to detect them by any ordinary means, it is stated on good authority, that in a small scrap of radio-active material, hundreds upon hundreds of atoms may be continuously disintegrated every second and yet this process may continue in operation for hundreds and perhaps thousands of years before any appreciable change in weight could be detected. Moreover, we are assured that atomic disintegration is constantly proceeding in radium and some other substances, and it is legitimate to infer that

this action is not confined to obviously radio-active bodies, but that gradual change, at a much slower rate, is the common fate of all matter, which may therefore be broadly considered as only a transient manifestation of the ether, although it may appear to us as eternally permanent.

It is well known that the ordinary flame spectra of many elements, both solid and gaseous, may be modified or entirely changed under the influence of the electric arc or condensed electric discharge, and this fact, strengthened by additional evidence found in the spectra of the sun and of certain stars, has pointed to the resolvability of these elements into more simple constituents under certain conditions. Metals and other heavy elementary bodies however, if vaporized by intense heat, will solidify into their original form again on cooling, and elementary gases when condensed into liquids or solids by the action of extreme cold and enormous pressure, will expand again into their original state, with their qualities unchanged, when normal conditions are restored, thus indicating in each case, that the mechanism of the individual atom has not suffered any permanent disarrangement.

Neither heat nor cold nor any other physical influence, in degrees that are attainable by us, can apparently penetrate or affect these foundation stones of matter, for the forces at our command are incomparably weaker than those which control and maintain the integrity of the elemental atom.

The life history of a chemical atom may cover a period of existence which exceeds the millions and millions of centuries occupied by the birth and decay of a planetary system by as much as the latter exceeds one short moment of our existence, and it is difficult for our finite minds to form any adequate conception of these tremendous eons of duration.

Material bodies however do not consist only of aggregations of atoms, but contain also free electrons, although to what extent has never been clearly determined due to their possessing few, if any, of the physical attributes common to gross matter. There is reason to believe, however, that the apparent transit of electricity through conductors can only be effected by the migration of free electrons, and for this reason we may infer that in metals and other substances which conduct electricity freely, they must exist in vast quantities and also be in a very mobile condition. The hypothesis has indeed been advanced that the conductivity of metals may be directly proportional to the extent of the mean free path of the electrons which swarm within the interstices between their atoms. On the other hand it may be legitimate to suppose that bodies which do not normally conduct electricity contain few electrons, or rather that the electrons within their substance may be bound or fixed in a way which checks their mobility of action. The last hypothesis appears to be the more feasible because some substances which are non-conductors at ordinary temperatures acquire conducting properties when strongly heated.

It is not within the scope of this review to discuss at any length the intimate relationship which appears to exist between electrons and that *something* which is manifested to us as electricity, but it may not be out of place, to touch very briefly and superficially on this subject.

Electrons can be expelled from matter in many ways, and in every case they appear to carry with them a negative charge of electricity, leaving the substance from which they have been subtracted positively charged, but free electrons carrying positive charges have never been isolated. When matter is negatively charged it is therefore presumably due to the assimilation of free electrons. Attention may here be drawn to the anomalous fact that a so-

called positive charge of electricity is due to a deficiency of electrons, and a so-called negative charge is the result of their surplus accumulation. This reversed nomenclature, although a little unfortunate, does not affect final results in practical work, so the terms "positive" and "negative" are still commonly used in accordance with the original application given to them by Benjamin Franklin, and it is interesting to note that although he accidentally reversed his plus and minus signs, yet his so-called "single fluid" theory of electricity borders very closely upon our most recent conceptions.

Seeing that these modern views of electronic mechanism are largely due to the discovery of radio-activity, or at least that they have been greatly strengthened and reinforced thereby, a few remarks on the most important features which have led up to these profoundly interesting and important results may be acceptable.

Radio-activity was first observed as a new property of matter by Becquerel about nine years ago at the time when the then recent discovery of X rays by Roentgen had naturally stimulated scientific research. It had been generally known for some time previous to this that certain minerals possessed the property of absorbing or storing up light rays and afterwards emitting them as a phosphorescent glow visible in the dark. The fact that X rays are able to affect a photographic plate through substances that are opaque to visible light suggested the possibility of sunlight being absorbed and then emitted in some form of radiation similar to X rays. Becquerel had been experimenting along these lines and he had wrapped some sensitive photographic plates in folds of black paper and placed them in the sunshine with lumps of pitch-blende over them. The story goes that a sudden rain storm caused him to hastily bring them under cover and they were put away in a dark closet and forgotten for a day or

two. Becquerel then brought them out to expose them to sunlight once more, but thought he would first try to develop one of the plates to ascertain if the original short exposure had produced any effect. To his surprise he discovered that the lumps of pitch-blende had photographed themselves on the plate with a strength that appeared to be out of all proportion to the brief time of their exposure to sunlight. Becquerel's acute mind immediately suggested to him that some action must have taken place in the dark closet, and on repeating the experiment without any exposure to light, he found that the pitch-blende produced a photograph of itself on the sensitive plate through several folds of black paper, when kept in perfect darkness. This was certainly a wonderful clue, and it was the starting-point of a series of experiments with which the world is familiar, and which have immortalized the names of the Curies and other investigators whose labors have revealed to us the wonders of radio-activity as exhibited in radium, thorium, uranium and some other kindred substances.

Selecting radium as a representative of this class, its most interesting and important characteristics may be summarized as follows:

1. It has the property of affecting a photographic plate through certain materials which are opaque to visible light.
2. Its emanations will discharge an electrified body by ionizing the surrounding air and thus making it a conductor. This feature is so marked that it furnishes the most delicate test known for the detection of radio-activity.
3. It excites fluorescence in certain minerals, but this phenomenon is partly of a different character to the ordinary fluorescence or phosphorescence that is excited by their exposure to light rays, as will be noted later on.
4. It generates continuously an appreciable amount of heat, so that under proper conditions it will maintain a

temperature within itself two or three degrees higher than that of surrounding objects.

5. It has the property of imparting a temporary radio-activity to all substances in its neighborhood by the deposit thereon of an infinitesimally thin layer of radio-active particles derived from its emanation.

6. It has a very marked effect on living tissue, and tumors, ulcers, cancers and other malignant growths have been pacified and even cured by its application.

Dangerous burns may also be inflicted by using it indiscretely, and it is a curious fact that these effects, like burns from X rays, may not appear immediately, but may develop many days or even weeks after the application has been made.

We may now proceed to briefly consider the origin or cause of some of these extraordinary properties, drawing our information from the classical researches of Ramsay, Rutherford, Soddy, and a few other scientists who have given special and untiring attention to these matters.

Referring to previous remarks on the mechanism of the atom, it is conceivable that certain conditions may occur to disturb the equilibrium of the velocities and orbits of an electronic system constituting an individual atom, in which case it may become unstable and explode or fly to pieces, either partially or entirely.

The atomic weight of radium is believed to be about 225, and when one of these heavy atoms is disintegrated, a train of results will follow which point to a partial explanation of its remarkable properties.

1. Material atoms that have been commonly termed "alpha" rays or particles are projected from the disintegrated parent atom with varying velocities up to a maximum of about 20,000 miles per second. These particles are not radio-active; they have about twice the atomic weight of hydrogen atoms and they are believed to be in

fact atoms of helium. Although they are projected with a speed that far exceeds that of any other known form of moving matter, their velocity is slow when compared with that of free electrons, and they possess but slight penetrating power, being unable to pass through even a thin piece of paper. When they impinge on certain materials, as for example, fluorescent zinc sulphide, they produce little flashes of light. The scintillations thus produced are so numerous and minute that in the aggregate they present a faint phosphorescent glow to the unaided eye. On examination, however, with a magnifying glass of moderate power, say about twenty diameters, individual scintillations become visible and appear as a multitude of constantly changing and twinkling points of light in a dark or slightly luminous field. Sir William Crookes was the first to discover this beautiful phenomenon and he applied it to interesting service in his well-known spinthariscope.

2. The residuum of the parent atom after its primary disintegration and the projection of "alpha" particles, assumes the form of an intensely radio-active emanation or heavy vapor, which continues to spontaneously decompose, ejecting more "alpha" particles, and breaking up rapidly in successive stages into other more or less radio-active products, each one differing in some degree from its predecessor.

3. Free electrons are also expelled from these products, which are endowed with enormous velocities varying from 60,000 to 175,000 miles per second, thus, in their most rapid flight closely approximating the speed of light rays. These electrons always carry a negative charge of electricity and they are commonly termed "beta" rays. They were foreshadowed in Faraday's "radianc matter" and are believed to be identical with the cathode rays formed in a Crookes' tube. Each electron appears to possess a uniform mass of about $1/770$ of a hydrogen atom and collectively

they have considerable penetrating power, their intensity being only reduced about 50 per cent. by passage through two inches of air at atmospheric pressure or $1/50$ of an inch of aluminum. The tremendous velocity of these "beta" rays or free electrons, and likewise that of the comparatively massive "alpha" particles points to the almost inconceivably high orbital speed of the members of the electronic systems composing the parent atoms from which they are projected when these atoms are disorganized and broken up by interior disturbances.

4. Incidental with the expulsion of "alpha" particles and "beta" rays, ethereal pulses are propagated with the velocity of light rays and possessing strong penetrating power. These ethereal pulses are termed "gamma" rays and they are probably produced by the impact of the "beta" rays against the solid material of the radium compound in the same manner as X rays are evolved by the impact of cathode rays against the platinum target of a Crookes' tube. Their resemblance to X rays is further demonstrated by their power to produce fluorescence in platino-barium cyanide, a screen of which material gave to Roentgen his first accidental clue to the discovery of X rays.

5. After undergoing sundry transformations as already noted, with the evolution of "alpha" particles, free electrons, and "gamma" rays, the material is probably reduced eventually to some stable substance or substances, and the universal presence of lead in ores containing radium has suggested that this metal may be at least one of the final products.

Radio-active effects may therefore be classified under several different headings such as, for example, thermal, luminous, chemical, electrical, etc., thus corresponding with the manifestations of ethereal waves before referred to, although not confined within these limits.

To sum the matter up, these effects are believed to be the result of a spontaneous disintegration or breaking up of heavy and complex atomic structures into lighter and more simple atoms and free electrons, accompanied with the evolution of energy which, considering the small mass of matter involved, has been estimated by Rutherford to be at least a million times greater than that developed by the most violent chemical reaction; comparatively stable matter being eventually formed as a last residue.

It is not consistent with sound and progressive thought to believe that present views are infallibly correct. They may indeed be considered extremely crude in some respects and will doubtless be subject to many changes in the future. We trust, however, that our progress towards a realization of ultimate truth will be hastened, and that we may be led onwards and upwards to clearer conceptions and more intimate knowledge of the mechanism of matter and the manifestations of the universal ether.

I may fittingly conclude by quoting the words of Lord Kelvin, who for more than half a century has devoted much time and thought to the solution of these difficult problems. He says: "Overpoweringly strong proofs of intelligent and benevolent design lie around us, and if ever perplexities—whether metaphysical or scientific—turn us away from them for a time, they come back upon us with irresistible power, showing to us the influence of a free will through nature and teaching us that all things depend on one Everlasting Creator and Ruler."

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